NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD
SOUTH DAKOTA SUPPLEMENTS ITALICIZED

IRRIGATION WATER CONVEYANCE

STEEL PIPELINE

(ft.)
CODE 430FF

DEFINITION

A pipeline and appurtenances installed in an irrigation system.

PURPOSE

To prevent erosion of loss of water quality or damage to land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

This standard applies to the design and installation of buried steel irrigation pipelines and steel irrigation pipelines permanently installed above ground. If soil conditions do not permit below ground installation, onground installation is restricted to pipelines not greater than six inches in diameter. Pipelines greater than six inches installed under those conditions shall be placed on aboveground supports. This standard is restricted to pipelines not greater than 48 inches in diameter and does not apply to short pipes used in structures such as siphons, outlets from canals, and culverts under roadways.

CONDITIONS WHERE PRACTICE APPLIES

The pipeline shall be planned and located to serve as an integral part of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

All areas served by the pipeline shall be suitable for use as irrigated land.

Water supplies and irrigation deliveries to the area shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

CONSIDERATIONS

Water Quantity

Effects on the water budget, especially on infiltration and evaporation.

Effects on downstream flows or aquifers that would affect other water uses or users.

Potential use for irrigation management.

Effects of installing a pipeline on vegetation that may have been located next to the original conveyance.

Water Quality

Effects of installing the pipeline (replacing other types of conveyances) on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water.

Effects on the movement of dissolved substances into the soil and on percolation below the root zone or to ground water recharge.

Effects of controlled water delivery on the temperatures of water resources that could cause undesirable effects on aquatic and wildlife communities.

Effects on wetlands or water-related wildlife habitats.

Effects on the visual quality of water resources.

CRITERIA

Laws and Regulations. *This practice must conform to all federal, state, and local laws and regulations. Laws and regulations of particular concern include those involving water rights, land use, land disturbed by construction, pollution* *control, property easements, wetlands, preservation of cultural resources, and endangered species.*

General. *All irrigation systems shall be operated in accordance with Irrigation Water Management (IWM) Plan.. IWM plans shall be in accordance with the South Dakota Standard for Irrigation Water Management - Code 449.*

Working pressure. The pipeline shall be designed to meet all service requirements without the use of a working pressure that will produce tensile stresses in the pipe greater than a design stress equal to 50 percent of yield-point stress. Design stresses for commonly used steel and steel pipe classes are shown in column two below:

Specification and grade of steel	Design stress 50 pct yield point
	lb/in.^{2}
ASTM-A-283	
Grade B	13,500
Grade C	15,000
Grade D	16,500
ASTM-A-570	
Grade A	12,500
Grade B	15,000
Grade C	16,500
Grade D	20,000
Grade E	21,000
AWWA-C-200	
Furnace butt weld	12,500
Grade A	15,000
Grade B	17,500
Grade X42	21,000

Computation of tensile stress in steel pipe must consider the following:

Maximum working pressure;
Inside diameter of the pipe;
Wall thickness of the pipe.

Computation of maximum working pressure must consider the following:

Maximum pressure from the pipeline profile and hydraulic grade line at design operating conditions;
Maximum static pressure;
Pressure due to water hammer, surge, or other transient pressures.

Corrugated metal pipes shall not be subjected to internal pressures greater than 20 feet of water (water tight seams and joints must be used).

Flow capacity. The design capacity shall be based on whichever of the following is greater:

Capacity to deliver sufficient water to meet the weighted peak consumptive use rate of the crops to be grown, or

Capacity sufficient to provide an adequate irrigation stream for the methods of irrigation to be used.

Minimum wall thickness. Minimum pipe wall thickness shall be as follows:

Welded Steel Pipe

Nominal diameter, inches	Wall thickness
4 - 12	14 gage less 12.5 %
14 - 18	12 gage less 12.5 %
20 - 24	10 gage less 12.5 %
26 - 36	3/16 inch less 12.5 %
38 - 48	1/4 inch less 12.5 %

Corrugated Steel Pipe

Nominal diameter, inches	Wall thickness
6 - 24	16 gage
30 - 36	14 gage
42 - 48	12 gage

Friction loss. For design purposes, the pipeline friction loss shall be based on Manning's Formula *using minimum roughness coefficient (n) as follows:*

Unlined Smooth Welded Steel Pipe	*0.012*
Inside Lined Smooth Welded Steel Pipe	*0.010*
Annular Corrugated Steel Pipe	
2 2/3 X 1/2 inch corrugations	*0.025*
3 X 1 inch corrugations	*0.027*
Helical Corrugated Steel Pipe	
1 1/2 X 1/4 inch corrugations	
8 inch diameter pipe	*0.12*
10 inch diameter pipe	*0.14*
2 2/3 X 1/2 inch corrugations	
12 inch diameter pipe	*0.011*
15 inch diameter pipe	*0.012*
18 inch diameter pipe	*0.013*
24 inch diameter pipe	*0.015*
30 inch diameter pipe	*0.017*
36 inch diameter pipe	*0.018*
42 inch diameter pipe	*0.019*
48 inch diameter pipe	*0.020*
3 X 1 inch corrugations	
36 inch diameter pipe	*0.022*
42 inch diameter pipe	*0.022*
48 inch diameter pipe	*0.023*

Check, pressure-relief, vacuum-release, and air-release valves. If detrimental backflow may occur, a check valve shall be installed between the pump discharge and the pipeline.

A pressure-relief valve shall be installed at the pump location if excessive pressure can build up when all valves are closed. Also, in closed systems where the line in protected from reversal of flow by a check valve and excessive surge pressure can build up, a surge chamber or a pressure-relief valve shall be installed close to the check valve on the side from the pump.

Pressure-relief valves shall be no smaller than ¼-inch nominal size for each diameter inch of the pipeline and shall be set at a maximum of five lb/in.^{2} above the safe working pressure of the pipeline. A pressure-relief valve or surge chamber shall be installed at the end of the pipeline if needed to relieve surge.

Air-release and vacuum-release valves or combination air-release and vacuum-release valves shall be placed at all summits in the pipeline, at the end of the line, and between the pump and check valve if needed to provide a positive means of air entrance or escape.

Air-release and vacuum-release valve outlets shall be *as shown below*.

Air-relief Vac-release Diameter inch	*Pipe Diameter inch*
1/2	*<4*
1	*5 - 8*
2	*10 - 16*
4	*18 - 28*
6	*30 - 36*
8	*38 - 48*

For pipelines larger than 16 inches in diameter, two inche air-release valves may be used in place of the sizes indicated if they are supplemented with vacuum-release valves that provide a vacuum-release capacity equal to the sizes shown.

Drainage and flushing. Provisions shall be made for completely draining the pipeline if a hazard is imposed by freezing temperatures or if drainage is specified for the job.

If provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets may drain at all low places in the line. If drainage cannot be provided by gravity, provisions shall be made to empty the line by pumping

Outlets. Appurtenances for delivering water from a pipe system to the land, to a ditch, or to a surface pipe system shall be known, as outlets. Outlets shall have capacity to deliver the required flow:

To a point at least 6 inches above the field surface;

To the hydraulic gradeline of a pipe or ditch;

To an individual sprinkler, lateral line, or other sprinkler line at the design operating pressure of the sprinkler or line;

To the design surface elevation in a reservoir.

Pipe supports. Irrigation pipelines placed above ground shall be supported by suitably built concrete, steel, or timber saddles shaped to support the pipe throughout the arc of contact, which shall be not less than 90 degrees nor more than 120 degrees as measured at the central angle of the pipe. If needed to prevent overstressing, ring girder-type supports shall be used. Support spacing shall insure that neither the maximum beam stresses in the pipe span or the maximum stress at the saddle exceed the design stress values.

Thrust control. For aboveground pipelines with welded joints, anchor blocks and expansion joints shall *be* installed at spacings that limit pipe movement due to expansion or contraction to a maximum of 40 percent of the sleeve length of the expansion coupling to be used. The maximum length of pipeline without expansion joints shall be 500 feet. Aboveground pipelines with rubber gasket-type joints shall have the movement of each pipe length restrained by steel holddown straps at the pipe supports or by anchor blocks instead of normal pipe supports.

Anchor blocks usually are not required on buried pipelines. Expansion joints shall be installed, as needed, to limit stresses in the pipeline to the design values.

Thrust blocks shall be required on both buried and aboveground pipelines at all points of abrupt changes in grade, horizontal alinement, or reduction in size. The blocks must be of sufficient size to withstand the forces tending to move the pipe, including those of momentum and pressure, as well as forces due to expansion and contraction.

Joints and connections. All connections shall be designed and constructed to withstand the working pressure of the line without leakage and to leave the inside of the pipeline free of any obstruction that would reduce the line capacity below design requirements. On sloping lines, expansion joints shall be placed adjacent to and downhill from anchors or thrust blocks. If cathodic protection is required, high resistance joints shall be bridged to insure continuous flow of current.

Welded steel pipe may be connected by rubber gasket bell and spigot joints, flexible couplings or by welding.

Corrugated steel pipe must be connected by coupling bands using rod and lug connectors. Rubber or neoprene gaskets designed to be water tight at design pressure, must be under the band.

A dielectric connection shall be placed between the pump and the pipeline and between pipes with different coatings.

Corrosion protection. Interior protective coatings shall be provided if the pH of the water to be conveyed is 6.5 or lower. Cement mortar coatings may be used if the water to be conveyed has a pH of 5.5 or higher and a sulfate content of 150 ppm or less.

All pipe exteriors for underground lines must be fully protected against corrosion. To meet protection requirements, all pipe must be coated and must be provided with supplementary cathodic protection as specified in item 2 below:

A Class A protection coating shall be provided if the soil-resistivity survey shows that either (a) 20 percent or more of the total surface area of the pipeline will be in soil having a resistivity of 1,500 ohm-cm or less or (b) 10 percent or more of the total surface area of the pipeline will be in soil having a resistivity of 750 ohm-cm or less. A Class B coating shall be provided for pipe to be installed in soil having a resistivity greater than 1,500 ohm-cm.

Supplementary cathodic protection shall be provided if the soil-resistivity survey shows that any part of the pipeline will be in soil whose resistivity is less than 10,000 ohm-cm unless galvanized pipe is used. Pipe to soil potential shall be not less than 0.85 V negative referred to as a copper/copper-sulfate reference electrode, with the cathodic protection installed. The initial anode installation shall be sufficient to provide protection for a minimum of 15 years.

Cathodic protection shall be provided for galvanized pipe if the soil-resistivity survey shows that any part of the galvanized pipe will be in soil whose resistivity is less than 4,000 ohm-cm. Galvanized pipe requiring cathodic protection shall have a Class B coating.

The total current required, the kind and number of anodes needed, and the expected life of the protection may be estimated as shown below:

The total cathode current required may be estimated from the formula.

$$I_t = C\,[A_i / Re_1 + A_2 / Re_2 + \ldots A_n / R_{en}]$$

Where:

I_t = total current requirement in mA
A = surface area pipe in *square feet*
R_e = soil resistivity in ohm-cm
C = a constant for a given pipe coating

For design purposes, this constant shall be considered to be not less than 32 for Class A coatings and not less than 60 for class B coatings.

The kind of galvanic anode to be used depends on the resistivity of the soils in the anode bed location. If the resistivity of the anode bed is:

Less than 2,000 ohm-cm, zinc anodes shall be used;

Between 2,000 and 3,000 ohm-cm, either zinc or magnesium anodes shall be used; and

Between 3,000 and 10,000 ohm-cm, magnesium anodes shall be used.

Anodes shall not be required on pipelines if soil resistivity is greater than 10,000 ohm-cm.

The number of anodes needed to protect the pipeline may be estimated by dividing the total cathode current requirement of the pipeline by the current output per anode.

Thus:

$$N = I_t / I_m \text{ and } I_m = k / R$$

Where:

N = number of anodes needed
I_t = total current requirement in mA
I_m = maximum anode current output in mA
k = constant for a given anode
R = soil resistivity of the anode bed in ohm-cm.

The expected life of an anode, based on the use of 17 lb/ampere year for magnesium and 26 lb/ampere year for zinc and a utilization factor of 0.80, shall be computed as follows:

Magnesium . . . . . $Y = 47W/I_o$

Zinc . . . . $Y = 31W/I_o$

Where:

Y = expected life in years
W = weight of anode in lb
I_o = design anode current in mA = I_m unless resistors are used in anode circuit to reduce output

If resistors are used to reduce anode current output to increase service life, the number of anodes required shall be based on the regulated output of the anode rather than on the maximum output, I_m.

Preliminary soil-resistivity measurements to determine coating requirements and the approximate amount of cathodic protection needed may be made before the trench is excavated. For this purpose, field resistivity measurements shall be made *using the four-pin method as described in NRCS National Engineering Design Note 12, or samples for laboratory analysis shall be taken at least every 400 feet along the proposed pipeline and at points where there is a visible change in soil characteristics.*

If a reading differs markedly from a preceding one, additional measurements shall be taken to locate the point of change. Resistivity determinations shall be made at two or more depths in the soil profile at each sampling state; the lowest depth shall be the strata in which the pipe will be laid. The lowest value of soil resistivity found at each sampling station shall be used as the design value for that station.

After the pipe trench is excavated, a detailed soil resistivity survey shall be made as a basis for final design of the coating and the required cathodic protection. At this time, resistivity measurements shall be made in each exposed soil horizon at intervals not exceeding 200 feet. The lowest value of soil resistivity found at each sampling station shall be used as the design value for that station. If design values for adjacent stations differ significantly, additional intermediate measurements shall be made.

The four-pin method with standard pin spacing gives average resistivities of the soil profile to a depth of seven feet. Where either the pipe or the anodes are to be buried over five feet deep, additional readings shall be taken in the trench after excavation to confirm soil resistivities used in design.

Steel pipelines placed on the ground shall be limited to sites where the soil resistivity along any part of the pipeline is greater than 4,000 ohm-cm. Pipe at anchor or thrust blocks shall be embedded or attached rigidly with a holddown strap.

Above Ground Installations

All pipe installed above ground shall be galvanized or shall be protected with a suitable protective paint coating, including a primer coat and two or more final coating.

Minimum Cover for Buried Pipe

The pipe shall be placed deep enough below the land surface to protect it from hazards imposed by traffic crossings, farm operations, freezing temperatures, or soil cracking. The cover shall be a minimum of two feet, but in soils susceptible to deep cracking, the cover shall be a minimum of three feet.

If necessary to install the pipe at a lesser depth, adequate protection shall be provided by placing extra fill over the pipeline, constructing a fence or other surface barriers, or using extra heavy gage pipe.

If trenches are excavated in soils containing rock or other hard material that might damage the pipe or coating material, the trenches shall be excavated two to four inches deeper than required and then filled to grade with sand or fine earth.

Materials. All materials shall meet or exceed the minimum requirements of this standard.

PLANS AND SPECIFICATIONS

Plans and specifications for steel irrigation pipelines shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

OPERATION AND MAINTENANCE

An Operation and Maintenance Plan must be prepared for use by the landowner or operator responsible for operation and maintenance. The plan should provide specific instructions to insure the practice functions properly. Minimum requirements to be addressed in the Operation and Maintenance Plan are:

Prompt repair or replacement of damaged components is necessary. Check to make sure all valves and air vents are set at the proper operating condition so they may provide protection to the *pipeline. Remove foreign materials and vegetation that can interfere with proper valve operation.*

Maintain backfill over pipe and maintain vigorous vegetative growth where applicable.

Remove debris, litter, and any blockage that restricts capacity.

Avoid travel and tillage over pipelines.

Control rodent to prevent damage to pipeline and appurtenances.

REFERENCES

UDSA-NRCS National Engineering Field Handbook of Conservation Practices, Chapter 3, 15.

USDA-NRCS, National Engineering Design Note 12.

USDA-NRCS, National Engineering Handbook, Part 630 Hydraulics.